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COTTON PRODUCTS RESEARCH AT THE SOUTHERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION

by
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Statistics alone indicate that cotton has a proud past and an uncertain future--in the 1920's, its share of the domestic consumption of textile fibers was about 85 percent; at present, it is only about 54 percent. But add research to the statistics and the future immediately appears more promising. Utilization research on cotton, conducted with only a fraction of the support expended on synthetics, is responsible for the sale of about 2.5 million bales annually--more than 25 percent of the domestic consumption of cotton.

Many organizations have made notable contributions to strengthening cotton's competitive position through utilization research. Since 1941, the Southern Utilization Research and Development Division and its organizational predecessors have maintained a vigorous research and development program on cotton; it is now devoting almost 60 percent of its effort to this commodity. This article describes only one facet of this broad program--principal achievements in cotton products research.

Wash-Wear Cotton Textiles

All-cotton wash-wear textiles currently account for the annual consumption of about 1.2 million bales of cotton that would not otherwise be used. Through the years, fundamental and applied research by the Division's scientists has contributed materially to the development of new or improved wash-wear finishes. The basic information has been available to the industry for improving virtually all wash-wear processes and products.

The Division's research has been particularly beneficial to the development of wash-wear finishes based on formaldehyde, pyrimidinones, methoxymethyl uron, divinyl sulfone, and the dimethylol monocarbamates. Both wet and dry wrinkle resistance can be imparted to cotton by the formaldehyde treatment. Unlike many conventional wash-wear finishes, this one is durable to both laundering and chlorine bleaching. Several mills in the United States and abroad are producing wash-wear cottons by formaldehyde processes. Available from three chemical companies here and abroad, the pyrimidinone and uron agents have achieved limited commercial use where cost is secondary to quality. This use continues to expand as the demand for high-quality, wash-wear goods increases. Two commercial concerns have produced and employed cotton textile finishing agents containing derivatives of divinyl sulfone. Annual consumption of the carbamates for wash-wear is estimated at 4 million pounds, with an increase predicted at 7 million by 1970. The carbamate finishes are also used in increasing amounts for deferred curing, a technique for producing wash-wear garments with flat, unpuckered seams and durable creases. Two new finishing agents developed in recent research at the Southern Division--dimethylol hydroxyethyl carbamate and dimethylol isopropyl carbamate--appear particularly promising for this application.

Durably Pressed Garments

Durable press items are the current rage of the garment industry. They retain their shape, creases, smoothness, and neatness after repeated launderings, and never need ironing. Some attribute the basic idea for durable press to the cooperative effort of the Southern Division and the National Cotton Council. Division scientists began intensive research in the general area of wash-wear, durable creasing, and shape retention as early as 1955, and subsequently reported processes for garment treatment similar to those adopted by industry.

Because the original all-cotton durably pressed garments had low abrasion resistance, blends containing 50 percent or more of the synthetics have largely replaced 100 percent cotton in these uses, especially men's wear. However, Division research has recently made impressive progress in improving the performance of all-cotton garments, thereby improving cotton's competitive position in this market.

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It is generally accepted that crosslinking cotton cellulose to the extent necessary for superior wash-wear performance reduces resistance to abrasion and wear. In addition, the set configuration of the garments concentrates wear at creases and thick portions of the structure. Several ways have been found for counteracting these effects and improving the abrasion resistance of wash-wear and durably pressed cotton goods. They include proper selection of fabric; pretreatments such as slack mercerization; slack mercerization followed by stretching, especially of fabrics containing plied yarns; use of proper amount of crosslinking agent and avoidance of overcuring; use of polymers to coat fibers within the fabric structure, especially polymers that can be further polymerized or crosslinked; preferential crosslinking in selected regions of the fabric structure; use of selected polymers in conjunction with preferential crosslinking; vapor phase treatment of fabrics and garments with crosslinking agents and polymers; and blending of crosslinked cotton fibers with noncrosslinked fibers. Still better abrasion resistance has been obtained on trouser-weight fabrics by combining two or more of these approaches to give additive benefits.

In the Division's research, emphasis is presently on the refinement of individual treatments and the establishment of optimum combinations to give maximum abrasion resistance and wear life.

All-Cotton Stretch Products

Consumer demand for stretch and bulkiness in textiles for apparel, household, and industrial uses is rapidly increasing. Division research on imparting these properties to cotton has played a major role in opening and expanding markets for it in this important consumer area.

Several important applications have resulted from slack mercerization, an inexpensive process developed by Division scientists. The first stretch cotton made by slack mercerization was the all-cotton conforming bandage produced during World War II. This self-clinging, elastic bandage was used by the Armed Forces during the Korean conflict in place of the more expensive elastic rubber-rayon bandage, and later became available for retail and institutional markets. It is still manufactured by three major surgical gauze companies. The same basic process has been used to make diapers with one-way elasticity that permits conformation to body contours and results in a neater and smoother fit. More recently, two concerns have adapted the slack mercerization process to the production of knitted socks and undergarments with added comfort and stability. Division researchers have also successfully imparted the new dimension of moldability to all-cotton woven fabrics through use of the slack mercerization technique. There are many potential applications for moldable woven fabrics, and the availability of inexpensive moldable cotton fabrics will undoubtedly increase its markets. Another recent and promising research development is the use of slack mercerization to impart stretch properties and a look of richness and depth to cotton lace.

A new all-cotton stretch product--resin-treated, back-twisted cotton yarn--is ready for commercialization. In general, fabrics made from these crimped yarns have more stretch than those made by slack mercerization of woven goods and, therefore, will have different applications.

Over 30 companies in the United States and abroad now manufacture all-cotton stretch fabrics. Most of the yardage is going into apparel, but upholstery, slipcover, and base fabrics for coated materials are also produced. All-cotton stretch fabrics have many potential uses in household, apparel, and industrial markets. It is anticipated that cotton will be a strong competitor in markets that by 1975 are forecast to consume more than 2 1/4 million equivalent bales of all textile fibers.

Weather- and Rot-Resistant Cotton Fabrics

Another achievement concerns the many new or improved chemical finishes to prolong the service life and increase the utility of cotton goods by protecting them from the destructive action of weathering and microorganisms. Much of this research has been cooperative with the Canvas Products Association International and with the Foundation for Cotton Research and Education. Sizable military and commercial markets have opened for the various treated products, including tarpaulins, tentage, awnings, field coverings, ditch liners, irrigation pipes, tobacco shade cloth, truck and boat covers, and beach umbrellas.

One of the earlier finishes, based on lead chromate, has been used for years to increase the service life of shade cloth used by tobacco growers. A second practical, low-cost finish, produced with an acid colloid of methylolmelamine, has been used by industry to treat tentage, tarpaulins, boat covers, and other canvas goods products. Another weather- and rot-resistant product--partially acetylated cotton--was also found to be very resistant to heat; its commercial use as ironing board covers resulted from this discovery. Results of other research at the Division have aided major stripers and finishers in the United States and abroad to select suitable combinations of pigments to give maximum protection to the outdoor cotton fabrics they produce.

In more recent research, an efficient, inexpensive treatment for outdoor fabrics was developed from new zirconium-copper antimicrobial agents. The new agents, all components of which are commercially available, are resistant not only to microorganisms that cause mildew and rot but also to algae. Other advantages are their low cost, durability, lack of odor, and ease of application. A new colorless weather-resistant finish has also been developed, primarily to increase the service life of cotton fabrics used in coated products. Based on commercially available chemicals, trimethylolmelamine and zirconium acetate, the finish is highly resistant to microorganisms that usually attack and quickly destroy cotton. Its lack of color makes the finish particularly desirable for white or light-colored coatings. Further research on these and related types of antimicrobial agents is in progress.

Flame-Resistant Cotton Products

For more than a decade, scientists at the Southern Division have been engaged in research to develop effective, durable flame retardants for cotton products. Much of the work was done in cooperation with the National Cotton Council and the Army Quartermaster Corps, the latter of which also provided financial support. The research was quite productive--several of the flame-retardant finishes resulting from the work were commercialized. These finishes utilize tetrakis(hydroxymethyl)phosphonium chloride (THPC) in conjunction with other chemical components. One of the early successful finishes was based on THPC-methylolmelamine-urea, commonly referred to as the THPC amide finish. Initially a heat cure was employed with this process; a later improvement substituted a chemical cure at ambient temperatures. In the latter technique, a water-soluble precondensate of THPC and amides is chemically fixed in cotton fabrics with ammonia gas and ammonium hydroxide solution. The ammonia cure adds nitrogen to the finish to increase the degree of flame retardancy and, at the same time, tends to reduce the loss of fabric strength associated with the heat cure. One of the most highly effective and durable flame retardants for cotton was obtained by reacting THPC with tris(1-aziridinyl)phosphine oxide (APO) to create a thermosetting resin inside the fiber. Durable to laundering and drycleaning, cotton fabrics treated by the THPC processes are resistant not only to burning but also to shrinkage, mildew, rotting, and weathering. Since they retain their pliable and protective form after being charred, they continue to offer protection even after exposure to fires and high-temperature irradiation.

The THPC-based flame retardants have found numerous applications in both military and civilian uses. Initially they were used in military apparel, tentage, and other military fabrics requiring durable flame retardancy. The use of incendiaries and of high energy thermal radiation in warfare has increased the need for effective flame retardants. In space technology, fire-resistant cotton fabrics have been found suitable for use in flight suits and in uniforms for rocket fuel handlers. Increasing interest in safety has created a growing demand for flame-resistant textiles in various civilian uses, such as apparel and household textiles. Flame-retardant finishes based on THPC are also being used for bed sheets, pillow cases, and support linens in hospitals, homes for the aged, corrective institutions, schools, hotels, motels, and the like.

A recent, specialized application for the flame-resistant cotton textiles is their use in high-pressure oxygen chambers where surgery is performed on "blue babies" and other patients with impaired circulation. Besides being flame resistant, the treated textiles reportedly do not develop static electricity, which could ignite the oxygen and other flammable materials in the chamber.

In the industrial market, there is major interest in fire-retardant clothing for employees who work with molten or flammable materials or near open flames or sparks.

More than 46 million linear yards of cotton textiles have been treated with THPC-based flame-retardant finishes. Two major companies in the United States and one in England supply the key chemicals, THPC and APO. More than 20 fabric producers and 3 nationwide laundries with more than 100 plants process cotton fabrics for flame resistance.

Current research at the Division seeks to develop less expensive durable flame retardants to further increase the acceptance of flameproofing finishes by industry, and thereby expand commercial production of flame-resistant cotton textiles. Treatments to simultaneously impart flame resistance and other desired textile properties are also under investigation.

Improved Cotton Batting

"Cotton Flote"--a new chemically treated cotton batting with improved resilience, coherence, and dimensional stability-- was developed at the Southern Division in cooperation with the Textile Waste Association, the National Cottonseed Products Association, the National Cotton Batting Institute, and the Foundation for Cotton Research and Education of the National Cotton Council. Because of its improved properties and performance, the new batting product is competitive with all types of cushioning materials, including polyurethanes and foam rubber, which had been penetrating cushioning markets held by cotton batting. As a result of this new process, markets will be regained for cotton linters and textile wastes (raw material going into the batting) in fine upholstered furniture, mattresses, and seats of automobiles, airplanes, and other vehicles. Molded cotton batting products have also been made for applications in headliners, bucket seats, and crash pads by the automotive industry, and as padding in contoured furniture.

The use of cotton fibers by the automotive, furniture, and bedding industries represents potential cushioning markets that exceed $1 billion at the retail level. These markets are equivalent to 1 1/2 million bales of cotton linters and textile wastes annually.

Two major U.S. automobile manufacturers first approved Cotton Flote for use in some models of their 1965 and 1966 cars. A third auto manufacturer is expected to approve the product as soon as its suppliers achieve production potential. One bedding company is now using Cotton Flote in high-grade mattresses. At least 12 companies are either producing the batting or installing the process in their plants. Firms in many foreign countries, including Germany, Holland, England, Canada, Pakistan, India, Australia, Thailand, Mexico, Switzerland, Japan, and Ireland, have also requested information on the new process and product.

Insect-Resistant Cotton Bags

An estimated 65,000 bales of cotton a year are used to produce bags for packaging cereals going into the important Food for Peace Program and grains shipped abroad under Public Law 480. Because the cotton fabric can be reclaimed and used to make clothing, these bags are in great demand in developing countries. However, competition from synthetic and lined or multiwall paper bags poses a serious threat to the markets for cotton bags. These markets will probably be lost unless satisfactory insect-resistant cotton bags can be developed soon.

In cooperative research with USDA's Stored-Product Insect Research and Development Laboratory, Market Quality Research Division, ARS, Savannah, Ga., and the Textile Bag Manufacturers Association, scientists at the Southern Division have made encouraging progress in research to develop cotton bags designed to protect flour, cornmeal, and other milled cereals from attack by insects during shipping and storage.

Exploratory experiments have led to a process that appears quite promising for making cotton bag fabrics insect resistant. In this process, the openings in the weave of the fabric are first reduced by dampening the fabric to swell the cotton fibers and calendering the fabric to flatten the yarns; then the fabric is treated with a small amount of a combination of piperonyl butoxide and pyrethrins in a wax base. The purpose of the wax base is to help keep the repellent on the fabric where it can be most effective in preventing insect infestation. The process has no detrimental effect on later use of the fabric for clothing because washing the fabric removes the repellent and restores the fabric to essentially its original state.

Preliminary tests at the Savannah Laboratory with small bags made from cotton fabrics produced by this basic process gave such encouraging results that large-scale evaluation tests are now being undertaken there. The latter tests will include storing a total of about 75,000 pounds of flour and cornmeal in 100-pound bags for 18 months. All filled bags will be exposed to insect infestations throughout the tests.

At the Southern Division, emphasis in further laboratory experimentation will be on the evaluation of materials that might be more effective than the wax base as carriers for the insect repellents.

Cotton Products With Other Special Properties

Numerous consumer preference surveys have shown that a great potential demand exists for cotton textiles that are more lustrous without sacrifice of functional properties. Researchers at the Southern Division have recently produced cotton fabrics that combine permanent luster, excellent wash-wear properties, and extraordinarily high tearing strength. Special mercerization and tensioning treatments are the key to the luster and strength achieved. Further improvements in the products are being sought.

Other important research is directed toward the development of new and better fluorochemical finishes to give cotton durable oil- and water-repellency, and other reactive and additive finishes to improve cotton's soil resistance. Several promising approaches for imparting these desirable consumer properties to cotton fabrics have been delineated and are under investigation. If practical, economical processes can be devised, cotton should gain additional markets.

Another active research area at the present time involves exploratory work to impart multifunctional properties to cotton through the use of specially tailored chemical compounds. In this research, a combination of several properties--including wrinkle resistance, rot resistance, flame resistance, and improved dyeability--are imparted to cotton in a single treatment. Recent work has culminated in the discovery of several new organophosphorus compounds having potential in multipurpose finishing.

New and extended uses for cotton are constantly being developed by the Southern Division and others; as the products are perfected and commercialized, the outlook for cotton will undoubtedly improve.

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